Frequency of Anatomical Variations of Paranasal Sinuses (PNS) In Patients of Chronic Sinusitis as Assessed by Computed Tomography

Tehreem Shan,[1] Sana Afzal,[2] Sameya Shireen,[3] Maryam Ahmad,[4] Humaira Riaz,[5] Zainab Riaz[6]

Abstract

Objective: To determine the frequency of anatomical variations of paranasal sinuses in patients of chronic sinusitis using computed tomography.

Material and Methods: It was a Cross-sectional study. The study was carried out at the Department of radiology, Armed Forces Institute of Radiology and Imaging, Rawalpindi from December 2020 to June 2021. A total of 310 patients of chronic sinusitis, of both genders and age 20-70 years were included. All these patients underwent Computed Tomography of Paranasal sinuses for detection of any anatomic variation in middle turbinate and findings were analyzed statistically.

Results: The mean age of the patients was 41.95± 11.24 years. There were 164 (52.9%) males and 146 (47.1%) females. On computed tomography, paradoxical middle turbinate was found in 69 (22.3%), deviated nasal septum in 166 (53.5%), middle concha bullosa in 22 (7.1%), superior concha bullosa in 12 (3.9%), haller's cells in 13 (4.2%), agger nasi cells in 8 (2.6%), maxillary hypoplasia in 3 (1%), septal spur in 12 (3.9%) and Onodi cells in 5 (1.6%).

Conclusion: The commonest anatomical variation in the paranasal sinuses as assessed on Computed tomography was deviated nasal septum followed by paradoxical middle turbinate and concha bullosa. Thus, computed tomography which is a safer and non-invasive imaging modality can help the treating physician about the cause of chronic sinusitis and also can guide about a better surgical approach.

Keywords: Anatomical variations, Paranasal sinuses, Sinusitis, Computed tomography

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Introduction

Chronic rhinosinusitis (CRS) is a prevalent condition that causes significant morbidity in individuals.[1] Clinical assessment and traditional anterior and posterior rhinoscopic examination are used to make the diagnosis, which is based on a number of frequently obscure physical complaints and symptoms.[1] The paranasal sinuses are one of the few organs in the human body that exhibit significant inter- and intra-subject variation.[2]

The current recommendations for the radiological examination of paranasal sinuses do not propose using traditional X-ray imaging modalities.[3] If a diagnostic imaging investigation is necessary, contemporary computed tomography (CT) is advised.[3,21] The value of radiographic imaging of the paranasal sinuses in the diagnosis of sinus disorders is, however, still debatable.[4] In this regard, it is critical to adhere to specific standards in order to limit the number of patients who request needless diagnostic imaging.[4] It is important to remember that unjustified CT scan requests from patients will result in unneeded radiation exposure and higher healthcare costs.[5] When medicinal therapy fails, endoscopic sinus surgery is considered, or there is a suspicion of

1. *Maroof International Hospital Islamabad*
2,6. *Islamabad Diagnostic Center Islamabad*
3. *Health next Diagnostic Center Islamabad*
5. *Benazir Bhutto Hospital Rawalpindi*

Correspondence:
Dr Zainab Riaz, *Assistant consultant Radiologist Islamabad Diagnostic center; Islamabad. x_en@live.com*

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cancer, CT imaging is recommended.[5] According to the research, CT imaging should be utilized to identify anatomical variations and disease patterns before surgery, especially in situations where endoscopic sinus surgery will be employed.[6] Functional endoscopic sinus surgery is the surgical technique of choice however due to the close proximity of paranasal sinuses to vital structures before hand CT is vital.[22]

While several studies in the literature link morphological abnormalities seen in CT evaluations of sinuses to particular sinonasal disorders like cystic fibrosis and clinical conditions like Kartagener syndrome, they also show that significant anatomical changes may be found in instances with no pathologies.[7] Regardless of whether the patient has mucosal sinus illness or not, at least one sinonasal anatomical alteration is present in 64% to 99.8% of patients.[7] Pneumatization of the paranasal sinuses is a complicated process that cannot be fully understood.[8] As a natural byproduct of this intricate process, several anatomical variances may be seen in this area.[9] Nasal septum deviation, concha bullosa or paradoxical middle concha, ethmoidal bulla hypertrophy, agger nasi cell, lateral or medial location of the uncinate process, Haller cell, and Onodi cell are among the structural changes found and often observed in paranasal CT imaging.[10]

There are various studies in the literature examining alternative viewpoints on this subject due to the large variety of anatomical variances in this location. However, there is paucity of local data. Therefore, the current study aims to determine the frequency of anatomical variations of paranasal sinuses (PNS) in patients of chronic sinusitis using computed tomography (CT). Details of anatomical patterns of PNS in our patients will help clinicians and surgeons in the early recognition of the possible cause of chronic sinusitis and to start empirical treatment on the basis of possible causes of chronic sinusitis. Also, identification of some anatomic variants is crucial in the planning of functional endoscopic sinus or other skull base surgery, because the presence of these variants may influence the surgical approach. Furthermore, if anatomical variations of paranasal sinuses are ignored then it may result in intraoperative complications because of close proximity to the blood vessels, nerves, orbits and brain.[22]

Material and Methods

It was a cross-sectional study. The study was carried out at the Department of radiology, Armed Forces Institute of Radiology and Imaging, Rawalpindi from December 2020 to June 2021. After the taking approval from Ethical Committee Ref No. IPC/004 dated 14-04-2022. A total of 310 patients of age 20 to 70 years, of both genders, who had chronic sinusitis and were referred to the department of Radio-logy for determining the anatomical morbidity of paranasal sinuses were included in the study. Patients who underwent any surgery of nose or sinuses, who were diagnosed as having active malignancy of nose or throat (diagnosed on medical record of the patient) were excluded. Enrollment of the patients was done after taking approval from the ethical review committee. Written informed consent was taken from all the participants. The sample size of 310 patients was calculated by taking the expected frequency of haller's cells as 5.0%,[6] at desired precision level of 2.5% and confidence level 95%.

The variations of the nasal septum that were assessed were paradoxical middle turbinate (PCMT), deviated nasal septum (DNS), middle concha bullosa, superior concha bullosa, haller's cell, aggernasi cells, maxillary hypoplasia, septal spur and onodi cells. PCMT was defined as a middle turbinate edge that curved inferomedially demonstrating its concave surface towards either of the middle septum and frequent bilateral presentation. DNS was defined as a deviation of the uncinate process free edge in a more lateral direction on either side which could be a potential reason for narrowed hiatus semilunaris and infundibulum. Middle concha bullosa was defined as the presence of air filled sacs on the vertical lamella of the concha. Superior concha bullosa was defined as the presence of air cells inside the superior turbinates. Haller's Cells were labeled by pneumatization of ethmoid air cells that were present along the medial roof of the maxillary sinus and the most inferior portion of lamina papyracea, below the ethmoid bulla and lateral to the uncinate process. Aggernasi cells were labeled when located within the lacrimal bone anterosuperior to the junction of middle turbinate with the nasal wall. Maxillary hypoplasia was defined as the underdevelopment of the maxillary bones that resulted in maxillary hypoplasia. Septal Spur was defined as an abnormal bone growth over the bony septum. Onodi cells were labeled when they were present at the superolateral aspect of sphenoid sinus and closely related to Cranial nerve II.

Demographic detail, clinical history and physical examination of all patients was carried out and findings were noted down on a predesigned proforma. All patients then underwent Computed tomography (CT) of the face

region to determine the anatomic variations of paranasal sinuses. Diagnosis of anatomic variations were made by a consultant radiologist who had an experience of at least 3 years following fellowship. The researcher assisted the consulted during the reportings of the CT scan and noted down all findings on a predesigned pro-forma. SPSS version 23.0 was used for analyzing the data. Quantitative variables such as age was presented as mean and standard deviation. Qualitative variables such as gender and anatomic variations of PNS were presen-ted as frequency and percentages. Stratification of data was done for effect modifiers such as age and gender. Post-stratification Chi square test was applied to deal with the effect modifiers and a p value of ≤ 0.05 was considered as significant.

Table 1: *Frequency distribution of Qualitative Variables*

Variables	N=310 Frequency (percentage)
Age Group:	
Young Age (20 -30 years)	59 (19%)
Early Middle Age (31 -45 years)	151 (48.7%)
Late Middle Age (46 -60 years)	84 (27.1%)
Old Age (61 -70 years)	16 (5.2%)
Gender:	
Male	164 (52.9%)
Female	146 (47.1%)
Anatomical Variants on Computed Tomography:	
Paradoxical middle turbinate	69 (22.3%)
Deviated nasal septum	166 (53.5%)
Middle concha bullosa	22 (7.1%)
Superior concha bullosa	12 (3.9%)
Haller's cells	13 (4.2%)
Agger nasi cells	8 (2.6%)
Maxillary hypoplasia	3 (1%)
Septal spur	12 (3.9%)
Onodi cells	5 (1.6%)

Results

The mean age of the patients was 41.95± 11.24 years. Distribution of patients according to age group is shown in Table-I. There were 164 (52.9%) males and 146 (47.1%) females (Table-I). On computed tomography, paradoxical middle turbinate was found in 69 (22.3%), deviated nasal septum (DNS) in 166 (53.5%), middle concha bullosa in 22 (7.1%), superior concha bullosa in 12 (3.9%), haller's cells in 13 (4.2%), agger nasi cells in 8 (2.6%), maxillary hypoplasia in 3 (1%), septal spur in 12 (3.9%) and Onodi cells in 5 (1.6%) **(Table-I).** Data was stratified for age and gender. Post-stratification Chi square test was applied. It was found that neither age (Table-II) nor gender (Table-III) had any significant association with the anatomical variations of paranasal sinuses.

Table 3: *Association Between Gender And Anatomical Variations of Paranasal Sinuses on Computed Tomography*

Anatomical Variation	Gender		Total	P Value
	Male	Female		
Paradoxical middle turbinate	39 (12.6%)	30 (9.7%)	69 (22.3%)	0.495
Deviated nasal septum	84 (27.1%)	82 (26.5%)	166(53.5%)	0.384
Middle concha bullosa	10 (3.2%)	12 (3.9%)	22 (7.1%)	0.468
Superior concha bullosa	7 (2.3%)	5 (1.6%)	12 (3.9%)	0.701
Haller's cells	9 (2.9%)	4 (1.3%)	13 (14.2%)	0.228
Agger nasi cells	3 (1%)	5 (1.6%)	8 (2.6%)	0.377
Maxillary hypoplasia	2 (0.6%)	1 (0.4%)	3 (1%)	0.631
Septal spur	7 (2.3%)	5 (1.6%)	12 (3.9%)	0.701
Onodi cells	3 (1%)	2 (0.6%)	5 (1.6%)	0.749

Discussion

Table 2: *Association between Age And Anatomical Variations of Paranasal Sinuses on Computed Tomography*

ANATOMICAL VARIATION	AGE GROUP				TOTAL	P VALUE
	YOUNG AGE	EARLY MIDDLE AGE	LATE MIDDLE AGE	OLD AGE		
Paradoxical middle turbinate	14 (4.5%)	34 (11%)	18 (5.8%)	3 (1%)	69 (22.3%)	0.973
Deviated nasal septum	26 (8.4%)	80 (25.8%)	49 (15.8%)	11 (3.5%)	166 (53.5%)	0.220
Middle concha bullosa	4 (1.3%)	14 (4.5%)	3 (1%)	1 (0.3%)	22 (7.1%)	0.441
Superior concha bullosa	5 (1.6%)	3 (1%)	4 (1.3%)	0 (0%)	12 (3.9%)	0.131
Haller's cells	3 (1%)	6 (1.9%)	3 (1%)	1 (0.3%)	13 (14.2%)	0.943
Agger nasi cells	2 (0.7%)	5 (1.6%)	1 (0.3%)	0 (0%)	8 (2.6%)	0.672
Maxillary hypoplasia	1 (0.3%)	2 (0.7%)	0 (0%)	0 (0%)	3 (1%)	0.682
Septal spur	2 (0.7%)	5 (1.6%)	5 (1.6%)	0 (0%)	12 (3.9%)	0.618
Onodi cells	2 (0.7%)	2 (0.7%)	1 (0.2%)	0 (0%)	5 (1.6%)	0.657

The current study revealed that on computed tomography, the commonest anatomical variations of PNS was DNS i.e. in 53.5% patients followed by paradoxical middle turbinate in 22.3%, middle concha bullosa in 7.1% and Haller's cells in 4.2% patients. Other less frequently seen anatomical variations were superior concha bullosa in 3.9%, septal spur in 3.9%, agger nasi cells in 2.6%, Onodi cells in 1.6% and maxillary hypoplasia in 1%. In terms of age of the patients, PCMT was commonly seen in early middle age and late middle age people i.e. in 11% and 5.8% respectively, DNS occurred more commonly in early middle age i.e. 25.8% followed by in late middle age patients i.e. 15.8%, middle concha bullosa was also frequently seen in early middle age group i.e. in 4.5% followed by in young age individuals (1.3%), superior concha bullosa was present more commonly in young age and late middle age group i.e. in 1.6% and 1.3% patients and Haller's cells were commonly found in early middle age group individuals i.e. in 1.9% patients. The rest of the anatomical variations were also frequently encountered in the early middle age patients. In terms of gender, males had higher frequencies of PNS (12.6%), DNS (27.1%), superior concha bullosa (2.3%), Haller's cells (2.9%), septal spur (2.3%) and Onodi cells (1%) compared to females, whereas in females, middle concha bullosa and agger nasi cells were more frequently seen i.e. in 3.9% and 1.6% respectively.

In this study, an average age limit was from 20 to 70 years with mean age of 41.95± 11.24 years which is very much comparable to the study of Al Anazy et al.[11] and Bist et al.[12] who had observed mean age of 33 and 34 years respectively while much higher than Adeel M et al[13] who had found mean age of 31 years. In the studies done by Ron G et al.14 and Al Anazy FH et al.[11], these anatomical variations in chronic rhinosinusitis patients were more frequent in females which contradicts with the results of this study in which male predominance has been found. On the other hand, Bist SS et al.[12] has shown the male dominance in his study which is a similar finding to our study. A review directed by Gupta et al.[15] on anatomic variations of paranasal sinuses (PNS) utilizing CT images revealed that deviated nasal septum (DNS) was seen in 78.8% patients, paradoxical middle turbinate in 46.10%, middle concha bullosa in 32.70%, superior concha bullosa 7.20%, haller's cells in 5.0% and agger nasi cells in 2.20% patients.[15] The frequencies of these findings are in line with our study which similarly revealed that DNS was the commonest anatomical variation followed by PCMT and concha bullosas. In a study by Sharma et al.[16], similar findings were yielded in terms of DNS being the commonest anatomical variation that was seen in around 68% patients. Tiwari et al.[17] also revealed that DNS was the commonest variation i.e. in 88.2 % followed by concha bullosa which occurred in 76.4% individuals, 9% had PCMT and 7% had agger nasi. These findings are in line with the findings of our study which similarly revealed that the commonest anatomical variation in PNS was deviated nasal septum and the other common ones were PCMT and concha bullosa. These findings in terms of commonest anatomical variations as detected by CT scan are not in line with the findings of Maru and Gupta,[18] who revealed that among patients with chronic sinusitis, anatomical variation that was most commonly present was Aggar nasi cells i.e. in 88.5% followed by DNS in 55.7% and Concha bullosa i.e. in 42.6%.[18] The commonest finding of Aggar nasi cells and lesser frequency of DNS is not in line with the results of the current study which revealed that DNS had a very high incidence and Agger nasi cells were very less i.e. in 2.6%. This difference in the anatomical variations in the paranasal sinus may be because of geographical difference. With the introduction of novel surgical procedures for treating sinusitis, particularly nasal endoscopic surgery, precise knowledge of anatomical variances is required, which may be discovered using multiplanar CT imaging that include axial, sagittal, and coronal views.[19] CT scan imaging may quickly catch up on minor variations that can be overlooked during surgical operations.[20] The current study had certain limitations. As the study was carried out at a single centre there is an issue of generalizability of the results. Secondly, the correlation of the findings with endoscopic findings was not done for the confirmation of anatomical variations of paranasal sinuses in patients with chronic sinusitis. Lastly, the effect of treatment outcome of patients who had anatomical variations were not assessed.

Conclusion

The current study concluded that the commonest anatomical variation in the PNS as assessed on CT scan was DNS followed by paradoxical middle turbinate and concha bullosa. So, we drew a conclusion that various variants of paranasal sinuses can easily be seen on CT imaging which is a non-invasive, less time consuming and much safer study. Having a brief sight to these variants preliminary to the surgical procedures can save patients from unwanted complications.

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Authors Contribution

T: Conceptualization of Project
S: Data Collection
S: Literature Search
H, M: Statistical Analysis
H: Drafting, Revision
ZR: Writing of Manuscript